

METHOD AND SYSTEM FOR SYNCHRONIZING RECEIVER SYSTEMS OF A WIRELESS LOCATION SYSTEM

This Application is a divisional of U.S. patent application Ser. No. 09/227,764 filed Jan. 8, 1999, now issued as U.S. Pat. No. 6,184,829.

FIELD OF THE INVENTION

The present invention relates generally to methods and apparatus for locating wireless transmitters, such as those used in analog or digital cellular systems, personnel communications systems (PCS), enhanced specialized mobile radios (ESMRs), and other types of wireless communications systems. This field is now generally known as wireless location, and has application for Wireless E9-1-1, fleet management, RF optimization, and other valuable applications.

BACKGROUND OF THE INVENTION

Early work relating to the present invention has been described in U.S. Pat. No. 5,327,144, Jul. 5, 1994, "Cellular Telephone Location System," which discloses a system for locating cellular telephones using novel time difference of arrival (TDOA) techniques. Further enhancements of the system disclosed in the '144 patent are disclosed in U.S. Pat. No. 5,608,410, Mar. 4, 1997, "System for Locating a Source of Bursty Transmissions." Both patents are owned by the assignee of the current invention, and both are incorporated herein by reference. The present inventors have continued to develop significant enhancements to the original inventive concepts and have developed techniques to further improve the accuracy of Wireless Location Systems while significantly reducing the cost of these systems.

Over the past few years, the cellular industry has increased the number of air interface protocols available for use by wireless telephones, increased the number of frequency bands in which wireless or mobile telephones may operate, and expanded the number of terms that refer or relate to mobile telephones to include "personal communications services", "wireless", and others. The air interface protocols now include AMPS, N-AMPS, TDMA, CDMA, GSM, TACS, ESMR, and others. The changes in terminology and increases in the number of air interfaces do not change the basic principles and inventions discovered and enhanced by the inventors. However, in keeping with the current terminology of the industry, the inventors now call the system described herein a *Wireless Location System*.

The inventors have conducted extensive experiments with the Wireless Location System technology disclosed herein to demonstrate both the viability and value of the technology. For example, several experiments were conducted during several months of 1995 and 1996 in the cities of Philadelphia and Baltimore to verify the system's ability to mitigate multipath in large urban environments. Then, in 1996 the inventors constructed a system in Houston that was used to test the technology's effectiveness in that area and its ability to interface directly with E9-1-1 systems. Then, in 1997, the system was tested in a 350 square mile area in New Jersey and was used to locate real 9-1-1 calls from real people in trouble. Since that time, the system test has been expanded to include 125 cell sites covering an area of over 2,000 square miles. During all of these tests, techniques discussed and disclosed herein were tested for effectiveness and further developed, and the system has been demonstrated to overcome the limitations of other approaches that have been

proposed for locating wireless telephones. Indeed, as of December, 1998, no other wireless location system has been installed anywhere else in the world that is capable of locating live 9-1-1 callers. The innovation of the Wireless Location System disclosed herein has been acknowledged in the wireless industry by the extensive amount of media coverage given to the system's capabilities, as well as by awards. For example, the prestigious Wireless Appy Award was granted to the system by the Cellular Telephone Industry Association in October, 1997, and the Christopher Columbus Fellowship Foundation and Discover Magazine found the Wireless Location System to be one of the top 4 innovations of 1998 out of 4,000 nominations submitted. The value and importance of the Wireless Location System has been acknowledged by the wireless communications industry. In June 1996, the Federal Communications Commission issued requirements for the wireless communications industry to deploy location systems for use in locating wireless 9-1-1 callers, with a deadline of October 2001. The location of wireless E9-1-1 callers will save response time, save lives, and save enormous costs because of reduced use of emergency responses resources. In addition, numerous surveys and studies have concluded that various wireless applications, such as location sensitive billing, fleet management, and others, will have great commercial values in the coming years.

Background on Wireless Communications Systems

There are many different types of air interface protocols used for wireless communications systems. These protocols are used in different frequency bands, both in the U.S. and internationally. The frequency band does not impact the Wireless Location System's effectiveness at locating wireless telephones.

All air interface protocols use two types of "channels". The first type includes control channels that are used for conveying information about the wireless telephone or transmitter, for initiating or terminating calls, or for transferring bursty data. For example, some types of short messaging services transfer data over the control channel. In different air interfaces, control channels are known by different terminology, but the use of the control channels in each air interface is similar. Control channels generally have identifying information about the wireless telephone or transmitter contained in the transmission.

The second type includes voice channels that are typically used for conveying voice communications over the air interface. These channels are only used after a call has been set up using the control channels. Voice channels will typically use dedicated resources within the wireless communications system whereas control channels will use shared resources. This distinction will generally make the use of control channels for wireless location purposes more cost effective than the use of voice channels, although there are some applications for which regular location on the voice channel is desired. Voice channels generally do not have identifying information about the wireless telephone or transmitter in the transmission. Some of the differences in the air interface protocols are discussed below:

AMPS—This is the original air interface protocol used for cellular communications in the U.S. In the AMPS system, separate dedicated channels are assigned for use by control channels (RCC). According to the TIA/EIA Standard IS-553A, every control channel block must begin at cellular channel 333 or 334, but the block may be of variable length. In the U.S., by convention, the AMPS control channel block is 21 channels wide, but the use of a 26-channel block is also known. A reverse voice channel (RVC) may occupy any